

# BLADDERWORTS OF INDIA

M.K. Janarthanam & A.N. Henry



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# **BLADDERWORTS OF INDIA**

**M.K. JANARTHANAM**

**AND**

**A.N. HENRY**

**BOTANICAL SURVEY OF INDIA**

**SOUTHERN CIRCLE**

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*Dedicated to the memory of Dr. K. Subramanyam, ex-Director,  
Botanical Survey of India, whose keen interest and fascination for the  
Indian bladderworts encouraged us to make a systematic study of them*

## FOREWORD

The present book "Bladderworts of India" is being published as a special publication under Flora of India series 4 Monographs. This comprehensive descriptive taxonomic monograph on Indian *Utricularias* with 35 species, is written and presented in complete form for the first time, and would serve as a useful manual to facilitate the identification of this highly specialised group of plants in India. A number of line drawings showing many noteworthy morphological details for the first time are of specific value to the botanists.

The subject matter of the book is a highly challenging one, for the delicate plants of *Utricularia* are poorly collected and are often incomplete in herbaria. The taxonomic position/status of several species has been suitably placed and distribution correctly recorded, after detailed field and laboratory/herbarium studies by the authors.

I am sure that the book will provide very useful information to all systematists and generate interest in the study of similar groups of plants in our country.

August 1991

**B.D. Sharma**  
Director  
Botanical Survey of India  
Calcutta

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Photo 1. *Utricularia aurea* Lour.



Photo 3. *Utricularia malabarica* M.K. Janarthanam & A.N. Henry



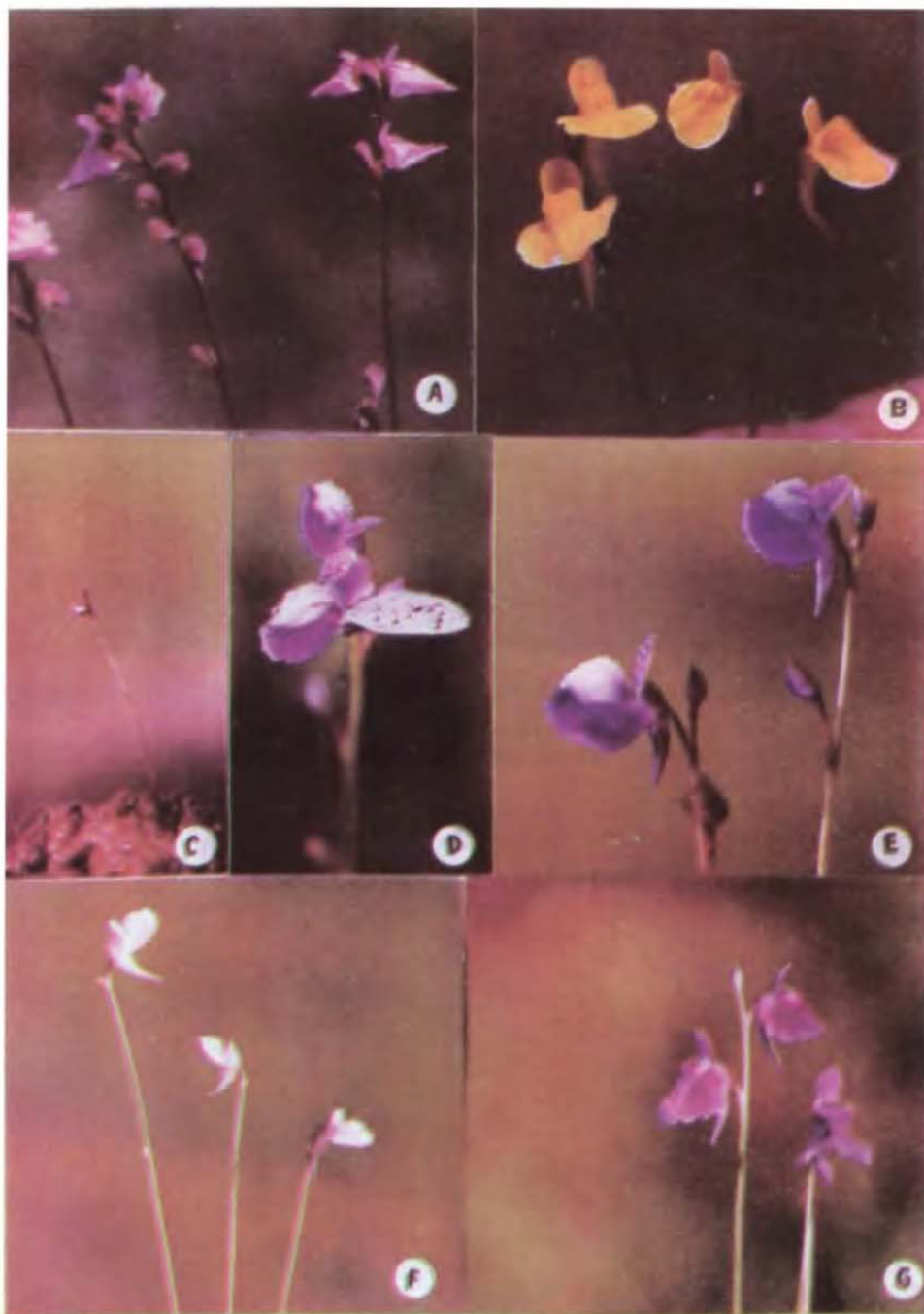


Photo 2. A. *Utricularia caerulea* L., B. *U. recta* Taylor, C. *U. minutissima* Vahl, D & E. *U. ceciliai* Taylor, F. *U. uliginosa* Vahl, G. *U. lazulina* Taylor

## INTRODUCTION

The legendary man-eating trees of Africa and Madagascar have long fascinated the popular press as well as the lay public. Though it is mythical, there are about 400 species of carnivorous plants, all herbaceous, belonging to five families of Angiosperms capable of trapping and digesting insects and animalcules. Among them the family Lentibulariaceae accounts for about 280 species. Of these, the Bladderworts, belonging to the cosmopolitan genus *Utricularia* L. with nearly 210 species is the largest and widely distributed mostly in tropical, subtropical and a few in temperate zones. This curious genus was little studied in India from the taxonomic point of view.

Oliver (1859) in his revisionary account treated 26 species of *Utricularia*. Later, Clarke (1884) recognised 22 species of *Utricularia* (and 10 imperfectly known species) for the then British India, including present India proper, and areas of Pakistan, Bangladesh, Nepal, Bhutan, Myanmar, Malaya and Sri Lanka. Moreover, due to the paucity of materials these publications could provide only inadequate descriptions and inaccurate concept of species resulting in much confusion on the identity and nomenclature of several species.

The reorganization of Botanical Survey of India in 1954 at Calcutta and opening of regional circles and field stations throughout the country have greatly helped in exploring the area under study. The specimens accumulated in Central National Herbarium at Calcutta and in regional herbaria of different circles however could not be correctly identified, due to the inaccurate keys and descriptions found in the earlier floras. Being a highly specialized and much variable group which needed time-consuming collection procedures, the general plant collectors could not pay much attention to this group; the importance of vegetative organs was also not recognised in the field. These have resulted in herbarium sheets, mostly with inflorescences without vegetative parts, faithfully pasted upon.

Further, it was observed that the various *Utricularias*, both aquatic and terrestrial, exhibit a high degree of variation in each of their features, leading to much confusion on their taxonomy and nomenclature. A detailed taxonomic revision of the family Lentibulariaceae for India was therefore felt essential and hence this challenging work was undertaken.

## THE AREA OF STUDY

The study area is restricted to the political boundaries of India, which covers an area of 3,267,500 sq. km, lying between 8° 4' and 37° 6' N. latitudes and between 68° 7' and 97° 25' E. longitudes. The mainland extends to 3,214 km from north to south and 2,933 km from east to west. India being the seventh largest country in the World, the land frontier stretches to 15,200 km and coastline to 6,083 km. It is bounded by the Himalayan ranges in north and northeast, Bay of Bengal in southeast, Arabian sea in southwest and Indian Ocean in south and politically bounded by Pakistan in northwest, Afghanistan, China, Nepal, Bhutan in north,

Myanmar in east and southwest and enclosing Bangladesh in east.

Geologically, it consists of three crust blocks: 1. Peninsular India, 2. Himalayan ranges and 3. Indo-Gangetic Plain. Among these, Peninsular India containing the Deccan plateau is geologically the oldest part of the country's land surface.

All the major landforms - hills, mountains, plateaus and plains are well represented in India. The principal mountain ranges in the country are: 1. Himalayas, 2. Patkai, 3. Aravalli, 4. Vindhya, 5. Satpura, 6. Sahyadri (Western Ghats) and 7. Eastern Ghats. Among these the Himalayas harbour most of the World's "eight thousander" (above 8000 m) peaks. They are the World's youngest and longest mountain system, extending east-west almost uninterruptedly for a distance of 2,500 km and covering about 500,000 sq. km. Glaciers are seen in the snowline between 4,000 and 6,000 m. in the Himalayas. These snowfields are the largest outside the polar region. The plains of India are the most important types of landforms from the standpoint of human use, which covers more than one million sq. km. They are extensively cultivated and densely populated wherever water is available. The river system includes the major rivers like the Indus, the Ganges, the Brahmaputra, the Mahanadi, the Godavari, the Krishna and the Cauvery. Apart from these, large lakes are present at all altitudes.

**Climate:** The temperature ranges from the average lowest of  $-34^{\circ}\text{C}$  in Dras to the average highest of  $47^{\circ}\text{C}$  in Mainpuri and Ludhiana. However the highest temperature recorded was  $50^{\circ}\text{C}$  on June 14, 1934 in Ganganagar.

**Seasons:** Each year can be conveniently divided into following four principal seasons: 1. Cold weather season - December to February; 2. Hot weather season March to May; 3. Southwest monsoon season June to September and 4. Retreating southwest monsoon season October to November.

**Rainfall:** Almost the whole of the subcontinent experiences the southwest monsoon during June and July. The northeast monsoon also contributes to a certain extent. These two monsoons are important for the Utricularias as they sprout up immediately after the rains. A place called Cherrapunji in Meghalaya receives the maximum rainfall in the World which averages to 11,418.7 mm, and the maximum rainfall recorded was 15,706.6 mm in the year 1951. The rains are minimum in the desert region of Rajasthan and snow covered Leh region of Jammu & Kashmir. Jodhpur recorded the lowest rainfall of 24.4 mm in the year 1899 (Anonymous 1983).

**Phytogeographical regions:** Clarke (1898), Hooker (1907), Chatterjee (1939) and Razi (1955) have divided India into many phytogeographical regions. Though the number of regions recognised by them varies, the following phytogeographical regions or botanical provinces are recognised by either one or the other: 1. Northwest Himalayas 2. Western Himalayas 3. Central Himalayas 4. Eastern Himalayas 5. Indus plains 6. Gangetic plains 7. Assam region 8. Central Indian and Deccan plateau 9. Malabar region and 10. Andaman region.

Politically, India has been divided into twenty five states and seven union territories.

## **SPECIES AND INFRA-SPECIFIC TAXA REPORTED FROM THE AREA**

History of the genus *Utricularia* in India starts with the publication of "Nelipu" by van Rhee (1689) in his "Hortus Malabaricus". Though Linnaeus (1753) published seven species of *Utricularia* in his species Plantarum, none of them was from the area under study. But, he had erroneously included "Nelipu" of van Rhee in *Utricularia caerulea* L. described from the specimens collected by Hermann from Ceylon (Trimen 1888; Basak 1979); "Nelipu" of van Rhee has since been identified as *U. reticulata* Smith.

Myanmarn (1768) reported *U. bifida* L. for the first time from India along with *U. caerulea*. But, again the latter included van Rhee's illustration. *U. stellaris* L.f. was the first species to be described wholly based on collection made from India by Koenig and described by Linnaeus (filius) in 1781. Willdenow (1797) published *U. capillacea* Willd. from India, but due to insufficient material its identity could not be established. Just at the end of the eighteenth century, Roxburgh (1798) had illustrated *U. stellaris* L.f. in his Plants of the Coromandel Coast. In the beginning of the nineteenth century, the first monograph of the family appeared, in which Vahl (1804) dealt with 34 species of *Utricularia*. Among them *U. graminifolia*, *U. flexuosa*, *U. uliginosa*, *U. humilis* and *U. ramosa* were the taxa described from India. Roxburgh (1820, 1832) treated *U. stellaris* L.f., *U. fasciculata* Roxb. and *U. diflora* Roxb. in Flora Indica. *U. hirta* a mss. name based on specimens collected from Southern India by Klein when he was attached to Tranquebar Mission near Madras was validated by Link in 1820. The names in Wallich's Catalogue (1828-1849) were either validated by later authors or published as synonyms.

De Candolle's Prodrumus (1844) dealt with all the species of *Utricularia* published until then, including many species from India, and he validated many names mentioned in Wallich's catalogue. Graham's catalogue of plants growing in Bombay and its vicinity (1839) included *U. purpurascens* Graham and *U. pusilla* Graham, two additional species. However, John Graham's catalogue did not deal with dried plants in a herbarium (Mabberley 1980). Benjamin (1845, 1847) described *U. alata* Benj., *U. paucifolia* Benj., *U. scandens* Benj., *U. squamosa* Benj. and *U. wallichiana* Benj., all from India. Edgeworth (1848) described a monotypic genus *Diurospermum* Edgew. (Type: *Diurospermum album* Edgew.), and also *Utricularia foveolata* Edgew., *U. polygaloides* Edgew., *U. pterosperma* Edgew. and *U. rosea* Edgew. from Bengal. Wight (1849, 1850) illustrated 24 species of *Utricularia* with notes and a key to the species. Of the above, 22 species were from India proper. *U. affinis* Wight, *U. arcuata* Wight, *U. brachypoda* Wight, *U. conferta* Wight, *U. glochidiata* Wight, *U. macrolepis* Wight, *U. pedicellata* Wight, *U. smithiana* Wight, *U. squamosa* Wight, *U. uliginoides* Wight, *U. wallichiana* Wight were described by him in the group. Dalzell (1851) described *U. albocaerulea* Dalz. and *U. decipiens* Dalz.

Oliver (1859) published the first ever monograph on Indian Utricularias.

He treated 26 species for India, including four new species (viz. *U. brachiata* Oliver, *U. furcellata* Oliver, *U. multicaulis* Oliver and *U. scandens* Oliver), two new varieties (viz. *U. wallichiana* Wight var. *firmula* Oliver and *U. reticulata* Smith var. *stricticaulis* Koenig ex Oliver), and *U. kumaonensis* Oliver - a new name. Drury (1866) had given a fine account of 17 species including five varieties for India.

Clarke (1884) treated 22 species of *Utricularia* (along with 10 names which were imperfectly known) for the whole of the then British India which also included parts of Pakistan, Nepal, Bhutan, Myanmar, Malaya and Sri Lanka. After, Hooker's Flora of British India (1872-1897), great emphasis was put on regional floras. Prain (1903) included 9 species in his Bengal Plants. Cooke (1905) treated 10 species of *Utricularia* for the Flora of Presidency of Bombay. Duthie (1911) accounted 4 species for upper Gangetic plains, and Haines (1922) listed 9 species for Bihar and Orissa in the family. Gamble (1924) treated 16 species of *Utricularia* for the then Madras Presidency; *U. roseopurpurea* Stapf ex Gamble and *U. stricticaulis* (Koenig ex Oliver) Stapf ex Gamble are two new species described in the work.

Santapau (1950) published an excellent account on Lentibulariaceae of Bombay. Taylor's (1964, 1977a) treatises on African and Malesian Utricularias included some species common to India. Subramanyam (1979) reviewed the work done on Indian Utricularias. In his taxonomic monograph on the genus *Utricularia*, Taylor (1989) included 33 species from India.

Several species of *Utricularia* have been described from India in the recent past. They are *U. equiseticaulis* Blatter & McCann and *U. ogmosperma* Blatter & McCann (Blatter & McCann 1931), *U. reticulata* Smith var. *parviflora* Santapau (Santapau 1949, 1950), *U. sampathii* Subr. & Yog. (Subramanyam & Yoganarasimhan 1981), *U. tayloriana* Joseph & Mani and *U. khasiana* Joseph & Mani (Joseph & Mani 1983), *U. praeterita* Taylor (Matthew 1983), *U. cecilii* Taylor and *U. lazulina* Taylor (Taylor 1984), *U. recta* Taylor (Taylor 1986), *U. nayarii* M.K. Janarthanam & A.N. Henry (Janarthanam & Henry 1986), *U. malabarica* M.K. Janarthanam & A.N. Henry (Janarthanam & Henry 1989) and *U. subramanii* M.K. Janarthanam & A.N. Henry (Janarthanam & Henry 1990).

Papers dealing with various aspects of morphology, taxonomy and nomenclature have been published by Abraham & Subramanyam (1965), Joseph & Ramamurthy (1961), Subramanyam (1962, 1977), Abraham et al. (1974), Subramanyam & Banerjee (1968), Basak (1976, 1979), Subramanyam & Yoganarasimhan (1979), Bhattacharyya (1976, 1986), Mehrotra & Chakraborty (1985), Srivastava (1983), Robins & Subramanyam (1980) and Janarthanam & Henry (1987, 1989). Apart from these, several State/District floras of India have also contributed to the morphology, taxonomy, ecology and distribution of the genus *Utricularia*.

## **PRESENT WORK:**

All the published names in the group from the study area and adjacent areas were indexed and protologues gathered from various libraries and herbaria.

Herbarium materials from the following herbaria were studied either by procuring on loan or by visiting them:

ASSAM	Kanjilal Herbarium, Botanical Survey of India, Eastern Circle, Shillong
BLAT	Blatter Herbarium, St. Xavier's College, Bombay
BSD	Botanical Survey of India, Northern Circle, Dehra Dun
BSI	Botanical Survey of India, Western Circle, Pune
BSJO	Botanical Survey of India, Arid Zone Circle, Jodhpur
CAL	Central National Herbarium, Botanical Survey of India, Howrah
DD	Forest Research Institute, Dehra Dun
LWG	National Botanical Research Institute, Lucknow
MH	Madras Herbarium, Botanical Survey of India, Southern Circle, Coimbatore
PCM	Presidency College Herbarium, Madras
SHC	Botanical Survey of India, Sikkim-Himalayan Circle, Gangtok

The specimens were collected with care in the field. They were lifted with the substratum in case of terrestrial species and slowly washed in water to remove the mud. The specimens which retain vegetative organs were given field numbers. A portion of the material was pickled using 50% alcohol and 5% glycerin or 50% alcohol following Taylor (1977b). Alcohol content was increased to 55% in the case of aquatic plants. The advantage in this process being, the material never became brittle, thus facilitating dissection. Specimens were dried for the herbarium keeping them in between blotters, after poisoning with absolute alcohol saturated with mercuric chloride. The dried specimens were mounted on standard herbarium sheets, properly labelled, identified and incorporated in the Madras Herbarium (MH). The details which could not be observed in dried specimens were noted in the field and transferred to herbarium sheets. These details include date of collection, place of collection, altitude, habitat, associated plants, frequency, distribution, flower colour etc.

The specimens received on loan as well as liquid preserved specimens were critically studied. A large number of illustrations were drawn, using translucent light in Olympus stereo microscope. The characters observed were tested with the characters mentioned in the literature. Circumscription of the taxa was delimited with the newly observed characters.

Protologues and type specimens were studied for all the names except for those mentioned otherwise. The type materials deposited in Indian herbaria were studied in original and those in the foreign herbaria studied either in the form of microfiche or photographs (cibachrome or black & white). All the names were typified and nomenclature brought up to date following the current International Code of Botanical Nomenclature (Greuter 1988).

Detailed descriptions, which clearly define the circumscription of various taxa, have been provided based on ample materials both pickled and dried. The special terminologies used in the descriptions were mostly adopted from Taylor (1964, 1977a) and Lawrence (1951). The taxa which could not be accommodated in known entities were described as new taxa. All the specimens studied for this work have been critically annotated and their correct identity and nomenclature established. The illustrations are selectively reproduced from copious drawings made during the study. These illustrations were drawn using Rotring pen; scale is given for all the figures. The dichotomous keys have been prepared on the basis of characters which are most reliable for identification.

The treatment of the genus includes its correct name and relevant synonyms with original citations and reference to important works and monographs, indication of type species, description, distribution, number of species for the World and for India, chromosome number(s) and pollen morphology. A key to the Indian species is provided. Under the genus the species are arranged alphabetically; the undeterminable and excluded species are treated at the end.

For each species the correct name is given in bold face. This is followed by all synonyms, in chronological order which are in italics. For the correct name and synonyms references to original publications, important floras, monographs/revisions and publications of taxonomic and distributional importance are given, along with the "type" details wherever available. Acronym of the herbarium, where the type is deposited is given in parenthesis and if the type specimen is examined for this work, it is indicated by the exclamatory mark (!). When photograph or microfiche is seen, it is clearly mentioned. The local names, if any, are mentioned next. An elaborate description of species is given, followed by flowering and fruiting season, habitat, distribution, chromosome number, pollen and notes in separate paragraphs. "Notes" under each species contain important and diagnostic characters of the species, nomenclatural aspects, etc. The specimens examined and studied are listed statewise and for each state in chronological order of collection with locality, name of collector, collection number and acronyms of herbaria where they are deposited. The names of states are arranged alphabetically. Reference to type photographs, wherever available is given at the end of original citation; reference to illustrations and photographs is given at the end of description.

The bibliography section includes references given in the text as well as general references useful for this study. The index to collectors provides collector's names arranged alphabetically with their collection number/Accession number, the corresponding species number in the text and the acronyms of herbaria where the collections are deposited.

An index to names of genera, species and infra-specific taxa is given at the end. The correct names are given in bold face and synonyms in italics.

These well-planned and intensive field and herbarium studies on the Indian bladderworts were completed in the end of year 1988. References to Taylor's (1989) monograph in the text were included at the stage of printing.

## OBSERVATIONS AND DISCUSSIONS

**Morphology and variations:** The bladderworts grow mostly in moist or aquatic situations. Their habit is modified to a great extent, displaying only the elegant inflorescence above the substratum. The vegetative organs in *Utricularia* are usually concealed underwater or sunk in mud or moss and due to the variation in habitats, their morphology also show noticeable variations.

**Roots/rhizoids:** True roots are absent in *Utricularia*, but root-like organs called rhizoids are present. Function of rhizoids is to provide anchorage. They can easily be identified by the absence of foliar organs on them. In aquatic species rhizoids are usually absent. But in *U. exoleta* the rhizoids are well developed with thick base and botryform branches as in *U. australis*. *U. aurea* rarely develops long, fusiform, float-like rhizoids at scape base. In terrestrial and epiphytic (partial) species they are well developed at scape base and often at axils of first and second scales in the former. Branches are usually simple and papillose.

**Stem/stolon:** True stem is absent in *Utricularia* and is substituted by stolons. In aquatic species they are submerged or floating in water and sometimes grow even up to 1 m long. *U. exoleta* shows circinate vernation and *U. minor* develops turions or winterbuds, when growing in cold climates. In terrestrial species the stolons are filiform, profusely branched and confined to mud. All epiphytic species have stolons except *U. furcellata*. *U. brachiata* develops tubers at base. As stolons are easily detachable, many collections, especially terrestrials are without foliar organs and traps.

**Foliar organs:** Though true leaves are absent in *Utricularia*, there are foliar organs, the equivalent of green parts in most species. Shape, size and pattern of nerves of these foliar organs are useful in broad taxonomic groupings (Fig. 1). The following types of foliar organs are noticed.

**DISSECTED FOLIAR ORGAN:** These are present in aquatic species, and the much dissected foliar organs were misinterpreted as roots by eighteenth century botanists. The number of primary foliar organs arranged semiverticillately, range from 3-5 (-6) in *U. aurea* and *U. stellaris* and occasionally with two stipule-like, dissected, auricular structures at base. The primary foliar organs are two in *U. australis*. Foliar organs divide just above the base and they further divide once or twice in *U. exoleta*. *U. minor* has polymorphic foliar organs, which are palmately divided. They vary in length and breadth. Traps are absent on short and broad foliar organs. In *U. minor* the apical foliar organs crowd together to form winterbuds or turions to overcome the winter season.



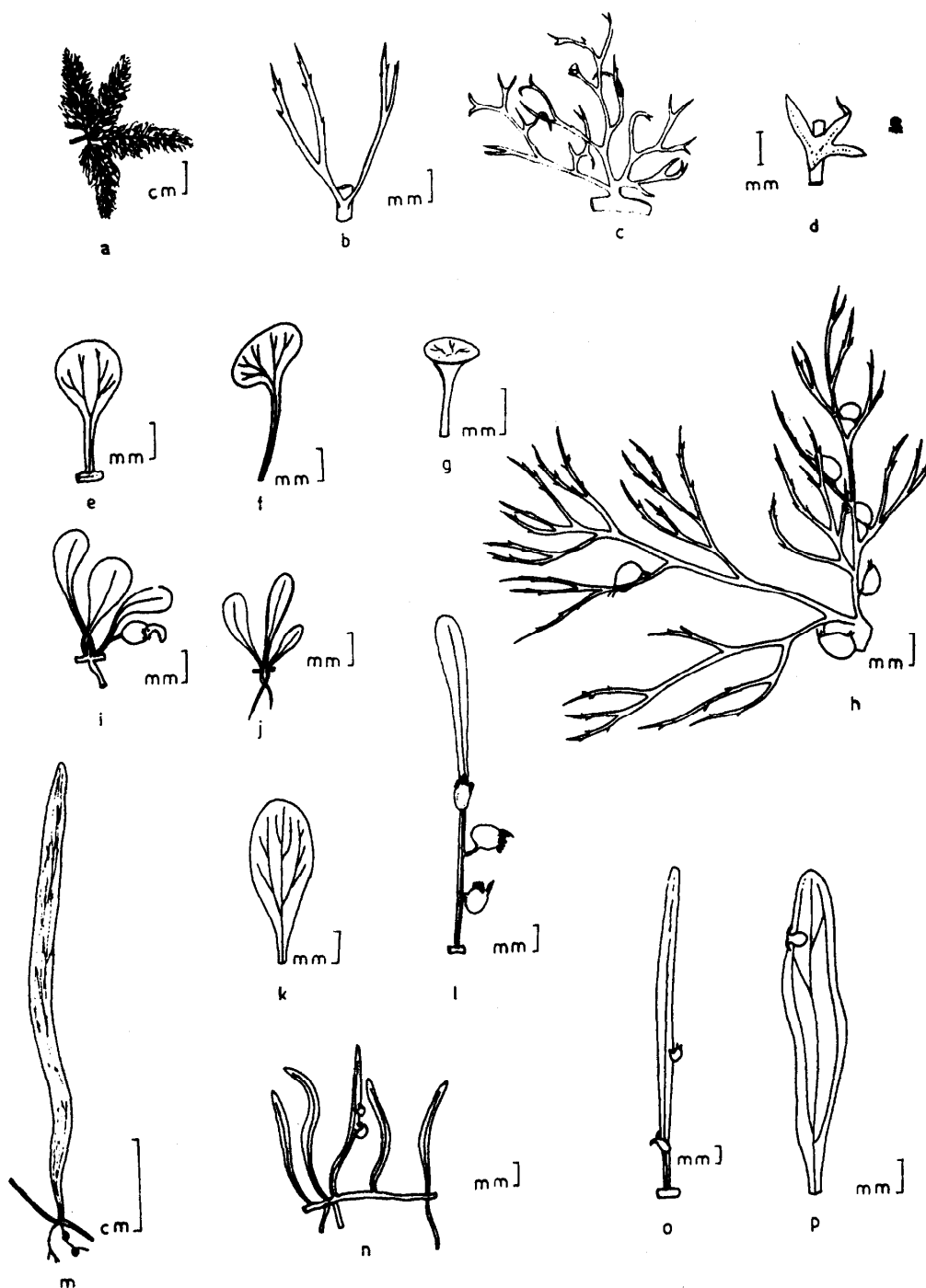


Fig. 1. Foliar organs: a. *Utricularia aurea*; b. *U. exoleta*; c, d. *U. minor*; e. *U. striatula*; f. *U. brachiata*; g. *U. pubescens*; h. *U. australis*; i. *U. roseopurpurea*; j. *U. caerulea*; k. *U. albocaerulea*; l. *U. hirta*; m. *U. nayarii*; n. *U. scandens*; o. *U. reticulata*; p. *U. graminifolia*.

**PELTATE FOLIAR ORGAN:** These are characteristic of *U. pubescens* with which we can identify the species.

**ONE-NERVED FOLIAR ORGAN:** 1-nerved foliar organs are of two kinds: 1. Linear as in *U. arenaria*, *U. bifida*, *U. foveolata*, *U. hirta*, *U. minutissima*, *U. polygaloides*, *U. recta*, *U. reticulata*, *U. scandens* and *U. subulata*; and 2. spatulate as in *U. caerulea* and *U. roseopurpurea*.

**THREE- OR MORE-NERVED FOLIAR ORGAN:** Foliar organs of certain species are 3-nerved; often these nerves branch further. These species are either widespread as in *U. uliginosa*, or restricted to the peninsular India and Ceylon as in *U. albocaerulea*, *U. ceciliai*, *U. graminifolia*, *U. lazulina*, *U. malabarica*, *U. nayarii*, *U. praeterita*, *U. purpurascens*, *U. smithiana* and *U. wightiana*.

The peltate, 1-nerved or 3-nerved foliar organs as mentioned above are present in terrestrial species. These foliar organs are present at scape base and on stolons with traps attached to them.

**ORBICULAR OR RENIFORM FOLIAR ORGAN:** These are characteristic of epiphytic species. The foliar organs are rosulate at scape base and scattered on stolons except in *U. furcellata*, where the stolons are absent. The pseudopetiole terminates in an expanded reniform structure in *U. brachiata*, or orbicular structure in *U. striatula*, *U. furcellata*, *U. kumaonensis* and *U. multicaulis*. Traps are absent on these foliar organs. The expanded portion shows dichotomous venation which is quite significant from the evolutionary point of view (Subramanyam & Yoganarasimhan 1979).

#### KEY TO THE SPECIES (INDIVIDUAL OR ASSEMBLAGE) OF *UTRICULRIA* BASED ON FOLIAR ORGANS

1. Dissected:
  2. Polymorphic *U. minor*
  2. Monomorphic:
    3. 3-5 per node *U. aurea* &  
*U. stellaris*
    3. 1-2 per node *U. australis* &  
*U. exoleta*
1. Entire:
  4. Orbicular to reniform:
    5. Reniform *U. brachiata*
    5. Orbicular to suborbicular:
      6. Present at scape base only *U. furcellata*
      6. Present at scape base and on stolons *U. kumaonensis*,  
*U. multicaulis* &  
*U. striatula*

4. Linear, spathulate or peltate:

7. Peltate

*U. pubescens*

7. Linear or spathulate:

8. 1-nerved:

9. Spathulate

*U. caerulea* &  
*U. roseopurpurea*

9. Linear

*U. arenaria*,  
*U. bifida*,  
*U. foveolata*,  
*U. hirta*,  
*U. minutissima*,  
*U. polygaloides*,  
*U. recta*,  
*U. reticulata*,  
*U. scandens* &  
*U. subulata*

8. 3 - or more nerved

*U. albocaerulea*,  
*U. cecillii*,  
*U. graminifolia*,  
*U. lazulina*,  
*U. malabarica*,  
*U. nayarii*,  
*U. praeterita*,  
*U. purpurascens*,  
*U. smithiana*,  
*U. uliginosa* &  
*U. wightiana*

**Traps:** The traps are insect capturing organs in *Utricularia*. They are also known as urceoli, ampullae, vesiculae, utriculae, pitchers, bladders or traps (Lloyd 1942). They are attached to vegetative organs (rhizoids, stolons and foliar organs) except in epiphytes where they are absent on foliar organs. These stalked structures have an orifice called mouth. The position of mouth to the point of attachment of stalk is important in broad classification. The trap opens inwards by a door. Bifid or quadrifid digestive glands are present within (Subramanyam & Abraham 1967). The appendages of traps also vary to a large extent, providing diagnostic characters (Fig. 2a-m). On the basis of position of mouth, traps of Indian *Utricularia* can be grouped as follows.

**MOUTH BASAL:** This kind of trap, where the mouth is situated near the stalk is present only in terrestrial species. The appendages are 2 and simple as in *U. graminifolia*, or branched as in *U. foveolata*. Sometimes a columnar structure develops on the stalks of *U. scandens* and *U. recta*.

**MOUTH TERMINAL:** Traps of this kind have mouth at the opposite side of the point where the stalk is attached. This type is found in terrestrial species only. The appendages are of numerous rows of comb-like gland-tipped hairs as in *U. arenaria* and *U. pubescens*, or a beak-like or sickle shaped structure as in *U. caerulea* and *U. roseopurpurea*.

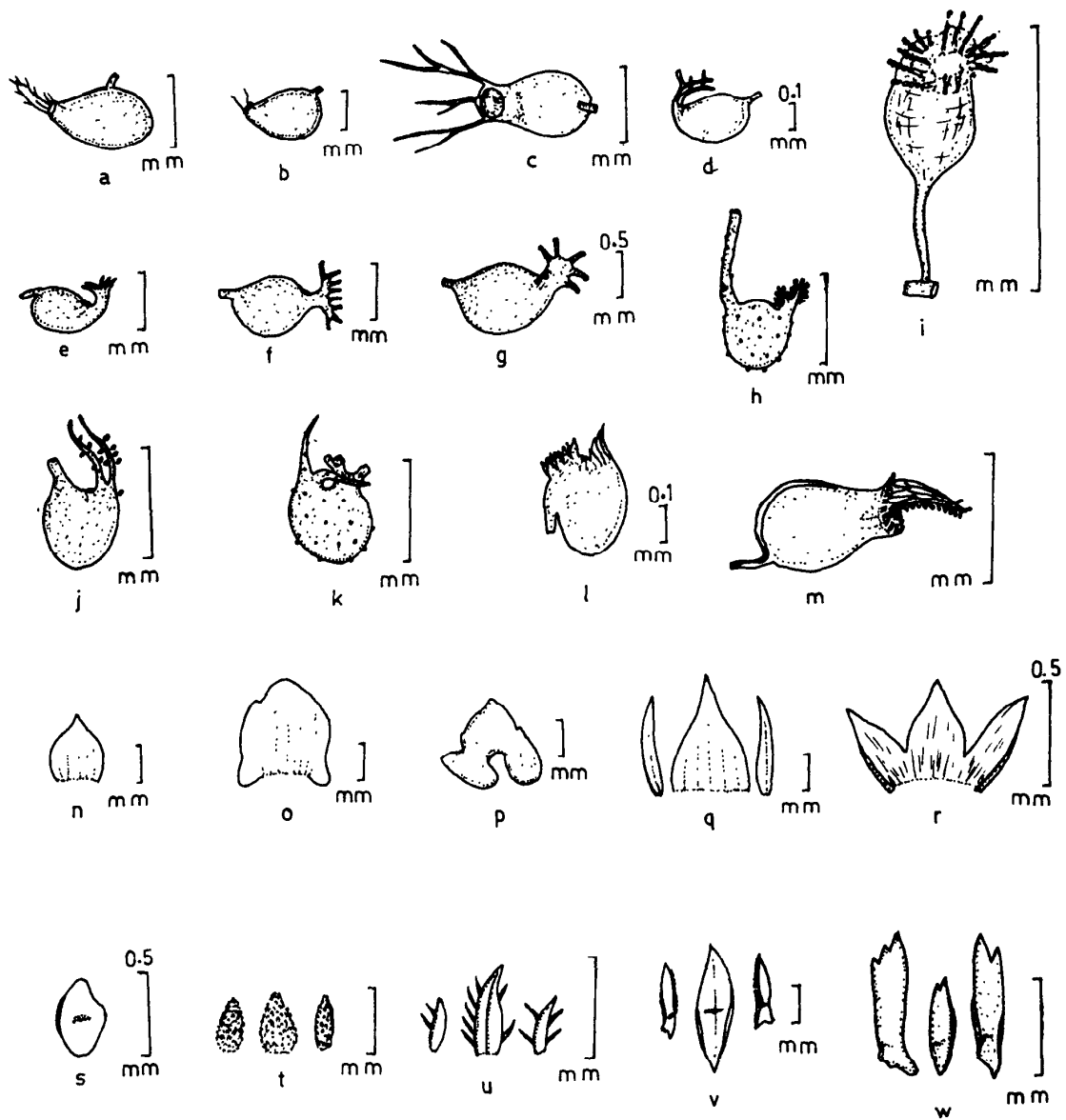


Fig. 2. Traps (a-m): a. *Utricularia stellaris*; b. *U. australis*; c. *U. exoleta*; d. *U. subulata*; e. *U. brachiata*; f. *U. furcellata*; g. *U. kumaonensis*; h. *U. striatula*; i. *U. pubescens*; j. *U. albocaerulea*; k. *U. scandens*; l. *U. hirta*; m. *U. caerulea*. Bracts & bracteoles (n-w): n. *U. aurea*; o. *U. australis*; p. *U. minor*; q. *U. cecili*; r. *U. minutissima*; s. *U. subulata*; t. *U. pubescens*; u. *U. hirta*; v. *U. roseopurpurea*; w. *U. kumaonensis*.

**MOUTH LATERAL:** All the aquatic and epiphytic species including few terrestrials have lateral mouth. In aquatics (eg. *U. aurea*) the mouth is oblique and appendages are subulate. The number of appendages ranges from 2-to many, or altogether absent. Epiphytes (eg. *U. striatula*) have the expanded upper lip with radiating gland-tipped hairs. Terrestrial species have two branched appendages as in *U. subulata*, or 3 connate processes (2-winged laterals and 1 subulate dorsal) as in *U. hirta* and *U. minutissima*.

The structure of traps is well explained by Lloyd (1942). Many papers on the function and mechanism of traps have appeared including the works from India by Ekambaram (1916, 1918, 1926).

### KEY TO THE SPECIES (INDIVIDUAL OR ASSEMBLAGE) BASED ON TRAP CHARACTERS

1. Mouth lateral:
  2. Upper lip expanded with radiating glandular hairs
 

*U. brachiata*  
*U. furcellata*,  
*U. kumaonensis*,  
*U. multicaulis* &  
*U. striatula*
  2. Upper lip not expanded:
    3. Mouth oblique
 

*U. aurea*,  
*U. australis*,  
*U. exoleta*,  
*U. minor* &  
*U. stellaris*
    3. Mouth circular:
      4. Appendages 2, branched
 

*U. subulata*
      4. Appendages 3 of connate processes
 

*U. hirta* &  
*U. minutissima*
1. Mouth terminal or basal:
  5. Mouth terminal:
    6. Appendages a beak-like structure
 

*U. caerulea* &  
*U. roseopurpurea*
    6. Appendages of comb-like radiating hairs
 

*U. arenaria* &  
*U. pubescens*
  5. Mouth basal:
    7. Appendages branched
 

*U. foveolata*
    7. Appendages simple:
      8. Columnar growth present on stalk
 

*U. recta* p.p.  
*U. scandens* p.p.

8. Columnar growth absent on stalk

*U. albocaerulea*  
*U. bifida*,  
*U. cecillii*,  
*U. graminifolia*,  
*U. lazulina*,  
*U. malabarica*,  
*U. nayarii*,  
*U. polygaloides*,  
*U. praeterita*,  
*U. purpurascens*,  
*U. recta* p.p.,  
*U. reticulata*,  
*U. scandens* p.p.,  
*U. smithiana*,  
*U. uliginosa* &  
*U. wightiana*

**Inflorescence:** In *Utricularia* spp. racemes are 1-many-flowered. The racemes emerge out of water in aquatic species. They are held up by spongy floats in *U. stellaris*, and rarely by inflated rhizoids in *U. aurea*. In terrestrial species the inflorescence is either twining as in *U. foveolata*, *U. reticulata* and *U. scandens*, or erect as in rest of the species. In *U. hirta* the inflorescence is hairy and in *U. pubescens* papillose.

**SCALE, BRACT, BRACTEOLE AND PEDICEL:** Scales are generally present on peduncles. They are absent in aquatic species like *U. stellaris*. In *U. aurea* the basifixed scales develop rarely. In *U. australis* and *U. minor* scales are auriculate. The scales are usually absent in partial epiphytes. Terrestrial species invariably have scales which are basifixed in majority of the species, or medifixed as in *U. caerulea*, *U. roseopurpurea*, *U. pubescens* and *U. subulata*.

Bracts are usually similar to scales in their shape and their position of attachment. They render important characters for identification. Bracteoles are present on either side of the bract, basifixed when the bract is basifixed, and medifixed or basisolute when the bract is medifixed. The bracteoles are equal to or longer than bracts in epiphytic species and terrestrial species with medifixed bracts, and are subulate in terrestrial species with basifixed bracts; in *U. hirta* and *U. minutissima* they are much broader.

**CALYX:** Calyx is 2-lobed and accrescent. In aquatic *Utricularias* calyx-lobes are equal or subequal; they are reflexed in *U. aurea*. In epiphytic species they are highly unequal and papillose. Calyx-lobes are hood-like and papillose in *U. caerulea* and *U. roseopurpurea*, hairy in *U. hirta*, and prominently nerved in *U. subulata*. Calyx-lobes are obtuse in *U. bifida*. Fruiting calyx-lobes are unequal in *U. nayarii* and *U. recta*.

**COROLLA:** The corolla is 2-lipped; colour of corolla varies from white, cream-coloured, yellow, blue, pink, purple, mauve to violet; upper lip varies in size and shape. Lower lip is 3-6-lobed in epiphytic species, and gibbous at base in terrestrial and aquatic species. A few species show characteristic spur, which is sickle-shaped in *U. purpurascens*; long and straight descending in *U. malabarica*; horizontal in *U. hirta*, *U. minutissima* and *U. caerulea*; and saccate in *U. minor*.

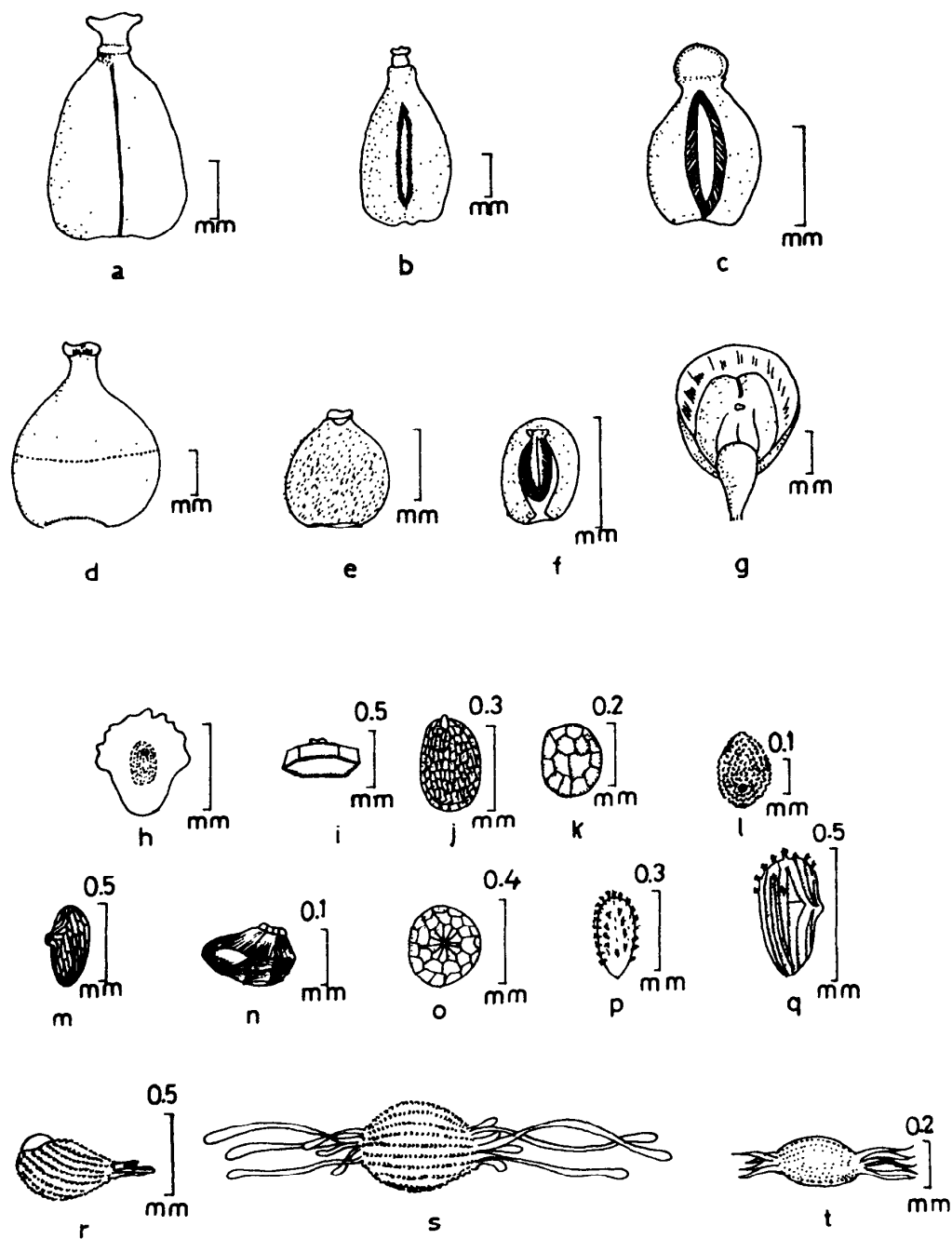


Fig. 3. Capsules (a-g): a *Utricularia smithiana*; b. *U. graminifolia*; c. *U. hirta*; d. *U. stellaris*; d. *U. caerulea*; f. *U. subulata*; g. *U. striatula*. Seeds (h-t): h. *Utricularia exoleta*; i. *U. stellaris*; j. *U. lazulina*; k. *U. hirta*; l. *U. roseopupurea*; m. *U. praeterita*; n. *U. reticulata*; o. *U. uliginosa*; p. *U. striatula*; q. *U. furcellata*; r. *U. multicaulis*; s. *U. kumaonensis*; t. *U. brachiata*.

Presence of cylindrical gland-tipped hairs on the spur of *U. aurea*, globose gland-tipped hairs on the spur of *U. stellaris*, and ligule on lower lip of *U. subramanii* are quite diagnostic.

**STAMENS:** Stamens are two, they are attached near to the base of upper lip, and the filaments are flat and often twisted. Anther thecae are distinct in many species, but confluent or subdistinct in epiphytes.

**PISTIL:** Pistil is equal to stamens in length. Ovary is globose to oblongoid, oblique in epiphytic species; placentation is free central or axile. Style is usually thick, flattened and much reduced. Stigma is 2-lipped, the upper usually reduced or represented by a small, subulate or dentate structure, and the lower orbicular to semiorbicular, often recurved and ciliate.

**CAPSULE:** The fruits render important characters in the broad classification of species. Capsule is globose and circumscissile in *U. aurea*, *U. minor* and *U. stellaris*, and 2-valved in *U. exoleta*. It is beaked in *U. aurea*. In epiphytes the capsule is oblique, partly attached to upper calyx-lobe and dehisce by a ventral, vertical slit. The capsule of *U. kumaonensis* is oblongoid and longer than calyx-lobe when compared with *U. multicaulis*, where it is subglobose and shorter than calyx-lobe. Surface of the capsule is papillose in *U. caerulea* and *U. roseopurpurea*. In other terrestrial species the capsule wall may be thickened along the dehiscent margin or uniform throughout. Those characters are useful in segregating certain species, which were earlier confused as in the case of *U. graminifolia*, *U. smithiana*, *U. wightiana* and *U. uliginosa*. (Fig. 3a-g).

**SEED:** Seed characters of *Utricularia* show greater variations as recorded by Abraham & Subramanyam (1965), Robins & Subramanyam (1980) and Taylor (1989). (Fig. 3h-t). They can be broadly classified as follows:

**WINGED SEEDS:** These are characteristic of aquatic species. They are lenticular, broadly corky-winged in *U. exoleta*, prismatic, 5-7-angled and slightly winged in *U. aurea*, *U. minor* and *U. stellaris*.

**SEEDS WITHOUT WINGS AND APPENDAGES:** These are characteristic of terrestrial species. Testa is tuberculate or papillose in *U. roseopurpurea*; scrobiculate with more or less isodiametric or slightly elongated cells in *U. nayaraii*, *U. smithiana*, *U. subramanii*, *U. uliginosa* and *U. wightiana*; and testa cells more or less isodiametric in *U. hirta* and *U. minutissima*. Testa cells are much elongated and compactly arranged in *U. albocaerulea*, *U. praeterita* and *U. purpurascens*. Testa has intercellular spaces in *U. cecillii*. Testa cells are finely striated within in *U. foveolata*, *U. bifida*, *U. polygaloides* and *U. reticulata*, and verrucose in *U. lazulina*.

**APPENDAGED SEEDS:** Much complicated seed structure is seen among epiphytic species. The seeds are glochidiate in *U. striatula* and *U. furcellata*, but the hilum is terminal in *U. striatula* and lateral in *U. furcellata*. *U. multicaulis* has echinate seeds with long appendages on one end of the seed only. *U. brachiata* and *U. kumaonensis* have seeds with appendages on both ends, but the testa is reticulate and smooth in the former, and echinate in the latter. The glochidia or appendages prevent the seeds from washing down to unfavourable substratum.



**KEY TO THE SPECIES (INDIVIDUAL OR ASSEMBLAGE) OF  
UTRICULARIA BASED ON SEED CHARACTERS**

1. Appendages present:
  2. Appendages glochidiate:
    3. Hilum terminal; seeds radially attached to placentum *U. striatula*
    3. Hilum lateral; seeds tangentially attached to placentum *U. furcellata*
  2. Appendages comose:
    4. Appendages on both ends of seed:
      5. Testa echinate *U. kumaonensis*
      5. Testa smooth, reticulate *U. brachiata*
    4. Appendages on one end of seed only *U. multicaulis*
1. Appendages absent:
  6. Seeds winged:
    7. Seeds lenticular, broadly corky winged *U. exoleta*
    7. Seeds prismatic, slightly winged *U. aurea, U. minor & U. stellaris*
  6. Seeds not winged:
    8. Testa striated within *U. bifida, U. foveolata, U. polygaloides & U. reticulata*
    8. Testa not striated within:
      9. Testa tuberculate or papillose *U. roseopurpurea*
      9. Testa reticulate and scrobiculate:
        10. Testa cells verrucose *U. lazulina*
        10. Testa cells not verrucose:
          11. Testa with intercellular space *U. cecillii*
          11. Testa without intercellular space *U. albocaerulea, U. arenaria, U. caerulea, U. graminifolia, U. hirta, U. malabarica, U. minutissima, U. nayarii, U. praeterita, U. pubescens, U. purpurascens, U. recta,*